Space Weather Technical Forecast

Issued on Saturday, 14 January 2023 at 12:42 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-class flares and R1/R2 radio blackouts Likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded by GOES16 has been Moderate over the last 24 hours, with a long-period peak M1.1 at 14/0207UTC seen from rapidly-emerging AR3191. This sunspot showed significant arcing towards the solar equator during the flare and left a filament channel in the aftermath (visible in AIA304), however no obvious Coronal Mass Ejection (CME) has since been identified on coronagraph imagery.

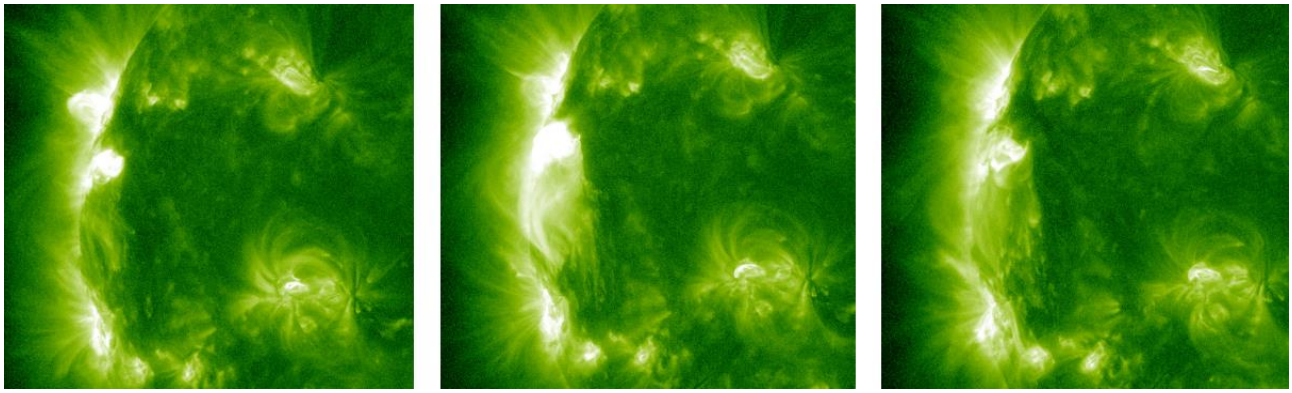

Figure 0: False-colour extreme UV imagery sequence from 14/0005 through 14/0215 to 14/0700UTC, showing the long-period Moderate-class X-ray flare from an arriving and growing sunspot region near the eastern solar horizon.

AR3191 itself lies in the vicinity of numerous active regions, with up to 13 total on the Sun's facing side at present. This group showed rapid development from a Zurich Dso to a Dsc in the 24 hours, with areal growth and proliferation of its constituent spots throughout. Other main events on the disc were the development of up to three small unnumbered regions; the approach of AR3181 to the southwestern limb making difficult to analyse (presenting as a Hrx/Alpha); the presence of tenuous Mt Wilson Delta spots in up to two regions (AR3186 (Eko/Beta-Delta) and AR3184 (Eso/Beta-Delta)); and finally the large areal size and containing plage of AR3190 in the southeast. This final group appears as a Ehi/Beta-Gamma, but may yet reveal more spots and span sufficient solar longitude to become a Zurich F-group. Other noteworthy mentions in terms of complexity rather than trends are AR3192, a Dsi/Beta in the northeast and AR3182, a Dai/Beta in the southwest.

No new Earth-directed CMEs have been identified on available imagery, including resulting from the aforementioned M-class flare, although this is being monitored. Also of note were possible disappearing filaments close to the northeastern limb at 14/0830UTC and the southeast at 14/1100UTC. A southwest-heading CME seen in coronagraphs during the UTC afternoon of Friday 13 January has been analysed as a miss, to no effect at Earth.

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Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE and DSCOVR at L1 showed an initial decline suggestive of a possible gradual exit from negative polarity coronal hole 62's influence. Around 13/2000UTC, this trend was abruptly interrupted in a number of measures by presumed 09 January CME influence, with ACE EPAM LEMS showing a sharp drop having previously been elevated.

The solar wind speed was initially on a near-flat trend around a Slightly Elevated 400km/s, but showed a slight discontinuity upwards at 13/1800UTC and especially at 13/2000UTC to rise to an eventual Elevated peak in the low-500s of km/s. The solar wind density showed initial single-figure ppcc counts rise to a peak of 15ppcc around 13/1830UTC, later moderating slightly around 10ppcc. The IMF opened out through the duration of the early UTC evening to peak at 11nT, with the north-south component ranging between +8 and -11nT. This was mainly anti-aligned with Earth's field during the UTC afternoon and early evening, but became more erratic thereafter. The phi angle was mostly negative - towards the Sun.

The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity, peaking at a provisional Kp '4+' in the 21-24UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 gradually reverted to Background levels in the wake of the slight enhancement entering the 24-hour period at 1pfu (i.e. below S1) earlier in the UTC day of 13 January.

High energy electron flux (greater than 2 MeV) was mostly at Normal Background levels, but with a Moderate peak of 327pfu at 13/1825UTC. The 24-hour integrated electron fluence stayed well below the Active threshold but showed a rising trend, reaching 5.17e6 integrated pfu at 14/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to continue at Moderate levels, with a Slight Chance of a Strong (X-class) flare.

Solar Wind / Geomagnetic Activity: Earth should undergo gradual exit from the 09 January CME influence and the tail of CH62 in the next 24 hours, with a Chance of Active intervals in the interim. An additional boost from a possible close pass of a CME may feature later in the UTC weekend, else activity should become increasingly Quiet into the new working week.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly Background levels, but with a Chance of further enhancements which could produce an S1 or greater event through the period.

The high energy electron flux (greater than 2 MeV) is Expected to continue at Normal Background to Moderate levels, with the corresponding electron fluence remaining below the Active (1e8 integrated pfu) threshold.

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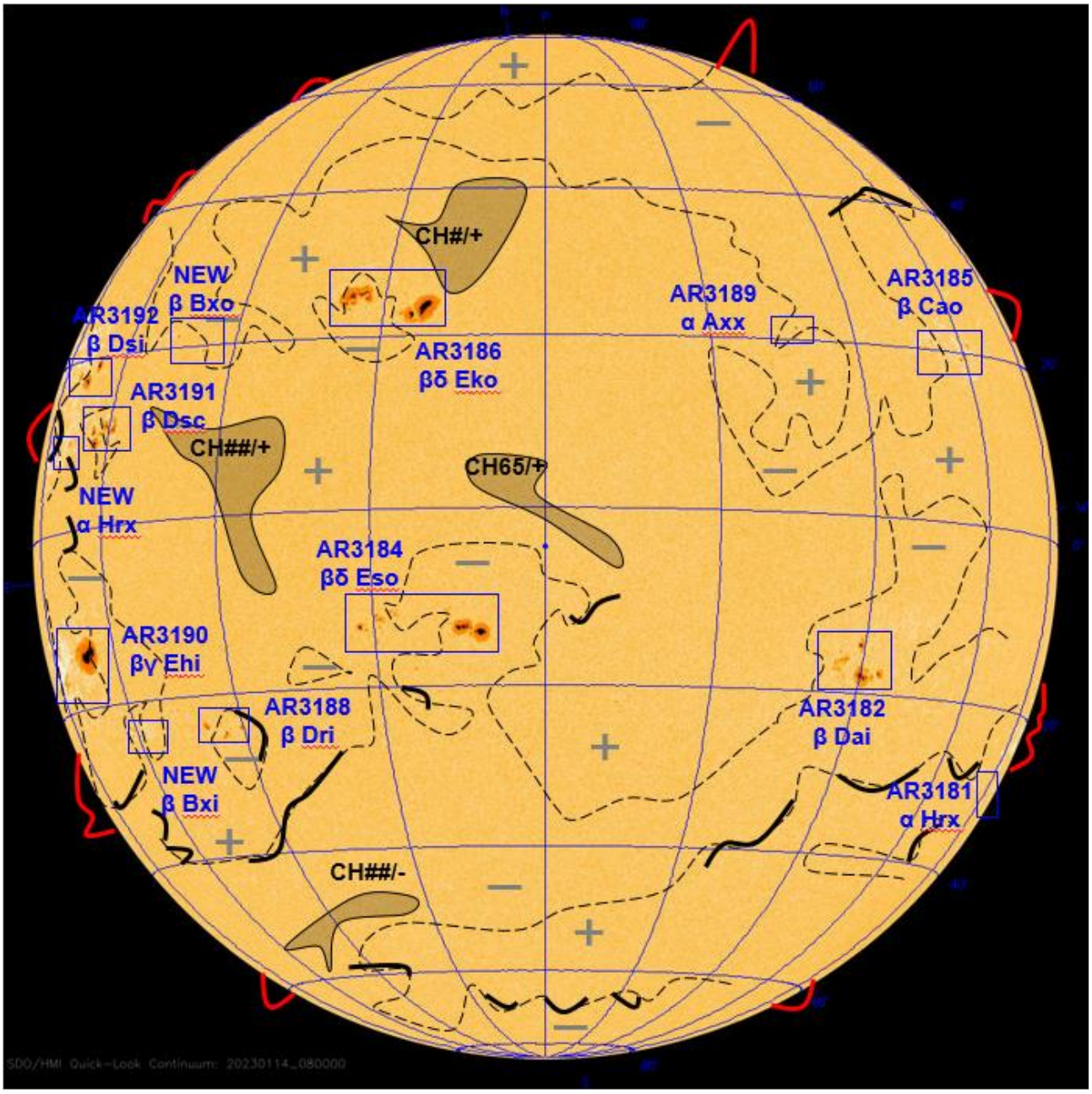
Figure 1. Solar Analysis Valid 14/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently thought to be under the influence of both the last vestiges of coronal hole 62, and also possibly the 09 January CME as of 13/2000UTC. A further CME is possible on 15 or perhaps 16 January from an eruption on 11 January, potentially giving some glancing interaction, although with very low confidence and diminishing risk of a G1 should it be on the later end of this arrival estimate.

Otherwise, any high speed stream effects from coronal hole 62 will wane, with no further coronal hole high speed streams forecast through the next four days. Coronal hole 65, analysed as a weak feature near the current solar meridian, is not expected to have any significant influence in the period, with MOSWOC Enlil suggesting arrival on 18 January. This is likely to be a volatile estimate given its lack of an analogue from last rotation, activity elsewhere on the disc perhaps altering its geometry, and its otherwise tenuous appearance.

Barring significant developments, geomagnetic activity is expected to highest earlier on in the four days, with a Chance of further Active intervals from the tail end of CH62 and the 09 January CME, giving way to similar from any further CME influence later in the UTC weekend. No other features should impact on the geomagnetic forecast into the new UTC week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
12/0939	Partial	AR3185	NW quadrant	500-550km/s	15/1200UTC	Glance possible. Low confidence.

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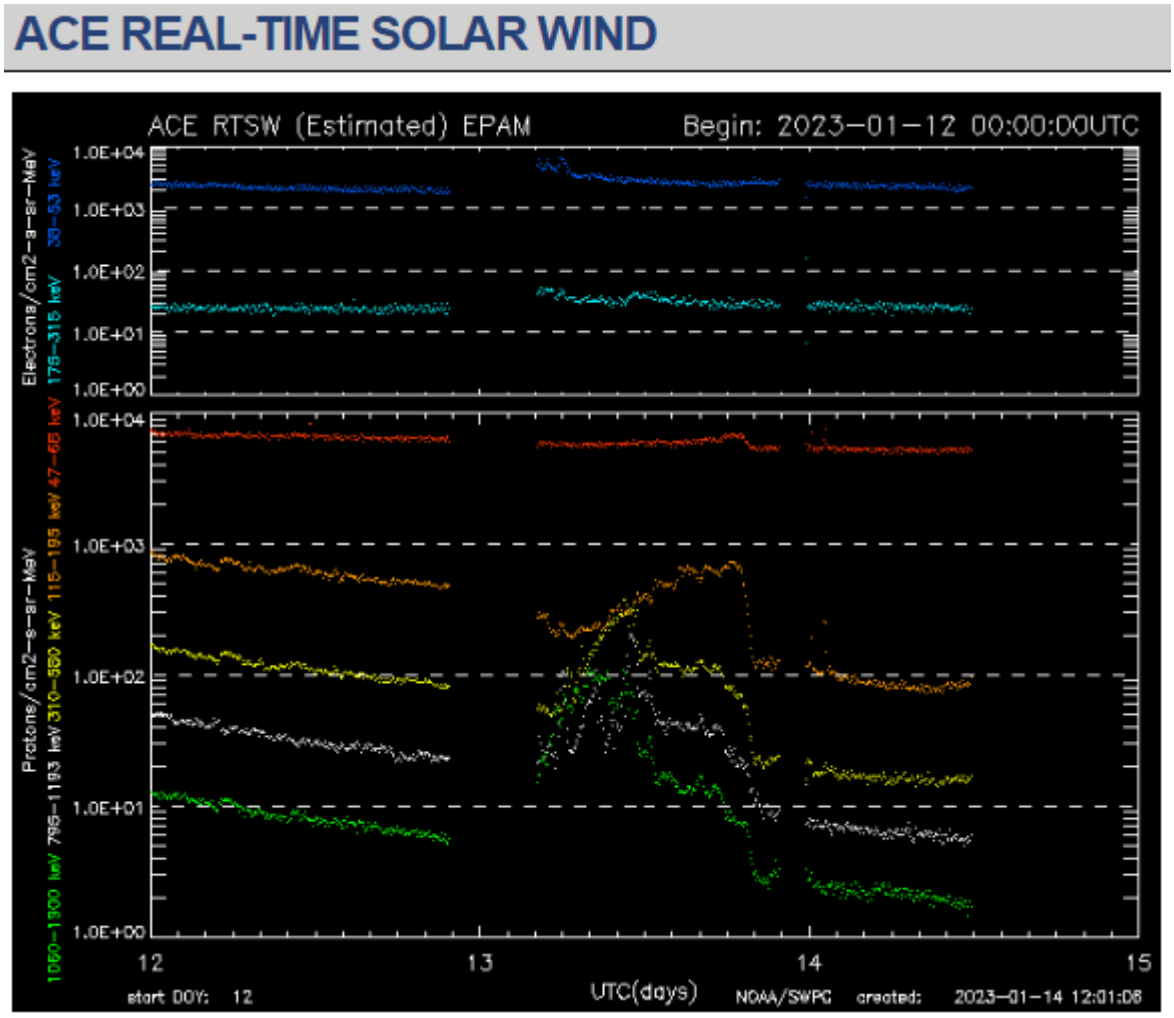
Figure 2: ACE EPAM LEMS trace for the past three days, showing a marked discontinuity around the time of the posited 09 January CME arrival.



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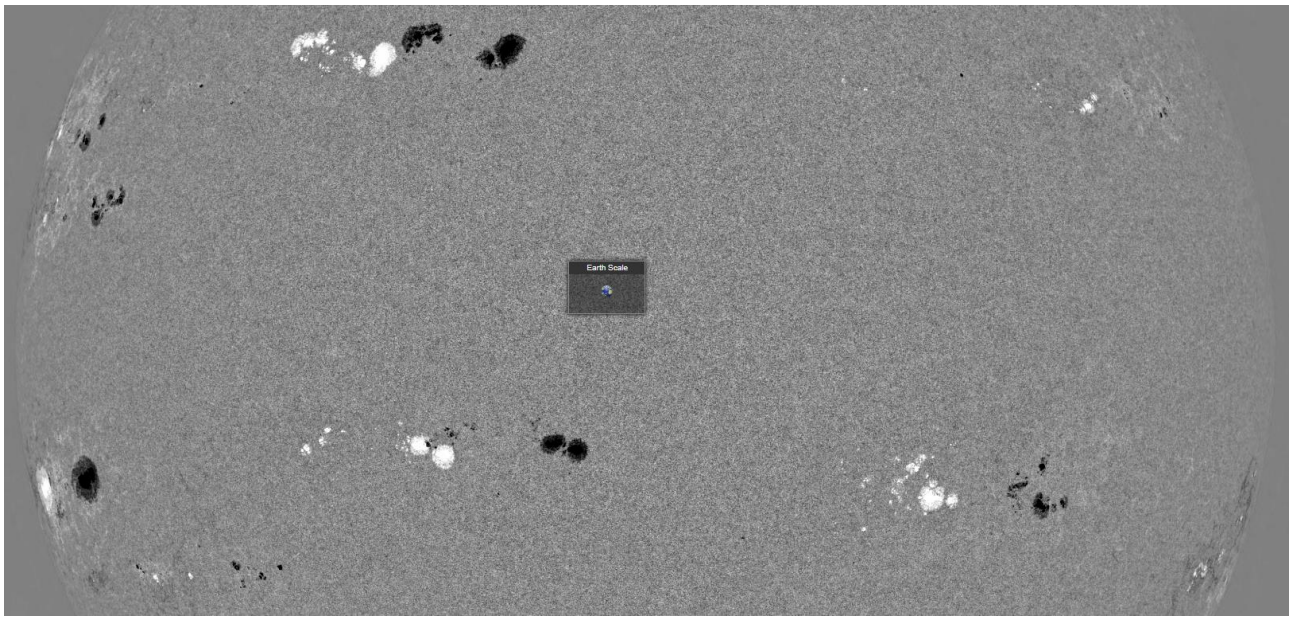
Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate over the last 24 hours.

The disc is now populated by up to 13 sunspot regions. AR3181 is likely to be hiding detail near the southwestern limb, but will shortly leave the disc. Up to three new regions have appeared near the eastern limb, with these also not fully presenting for analysis. AR3191 showed by far the strongest growth and proliferation of spots in the period, now showing as a Dsc/Beta. Other groups of note are AR3184, which has a possible Mt Wilson delta near its terminal trailer; as well as AR3186, which has similar present in the far north of its trailing group. AR3190 is likely to be hiding detail in its current presentation of a large plage and Ehi/Beta-Gamma set-up.
Solar activity is Likely to continue at Moderate levels, with further M-class flares and a daily Slight Chance of a Strong (X-class) flare.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	70	70	70	70
Very Active	**R3 to R5 X Class**	No	15	15	15	15

Figure 3: Helioviewer.org-generated 24-hour HMIIF footprint difference imagery for 13/1200UTC (white footprints of sunspot groups) to 14/1200UTC (black). The main development can be seen to be tied to AR3191 in the northeast, which has emerged from next to nothing over the past day. Earth shown for scale.



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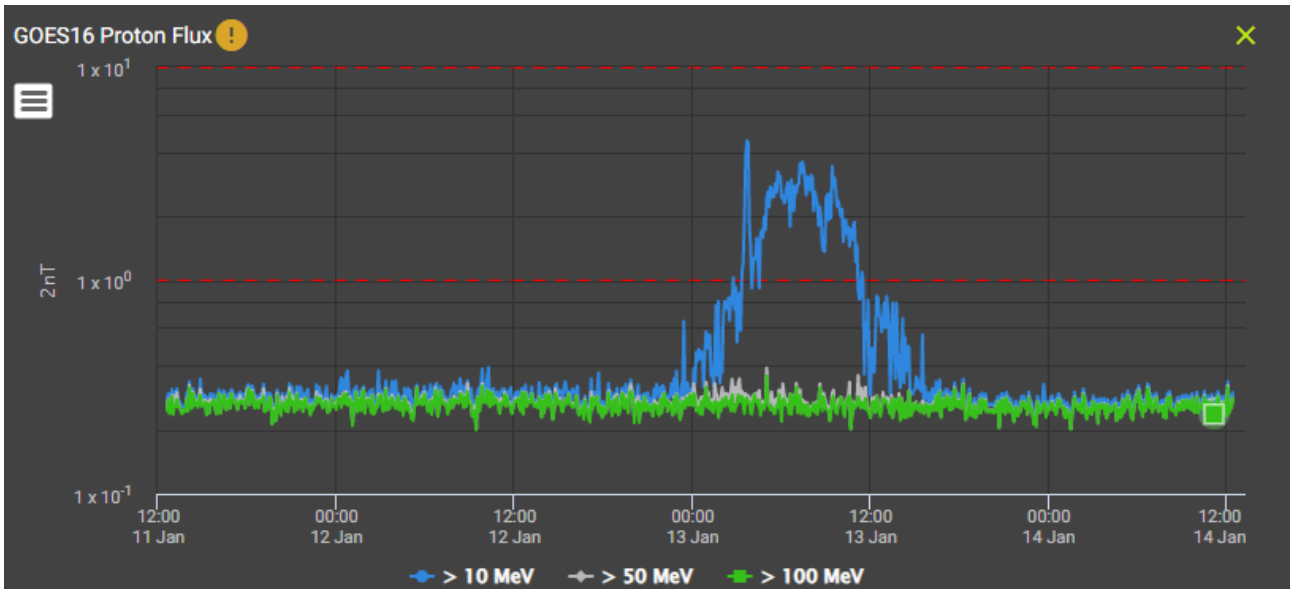
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10 MeV) proton flux observed by GOES16 showed an enhancement through 13 January, but has now returned to Background. This was thought to be due to a flare and concurrent CME event from just beyond the southwestern limb.

There is a Chance of further such enhancements which could produce an S1 or greater event through the period, with the risk reasonably well-spread amongst the 13 or so population of the Earth-facing side, as well as the recently departed western solar horizon spot groups. It is generally true to say that the eastern solar hemisphere is more heavily congested than the west, and as such the risk can be expected to rise - with all other things being equal - later in the coming week, although for now a flat trend near 30% is adopted.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	30	30	30
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 3-day GOES16 proton counts at GEO, showing a soft spectral response to a presumed generating event over the southwestern limb. Similar such activity is possible through the four-day period.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is expected to be at Normal Background to Moderate levels over the next four days in the absence of a strong high speed stream or any other significant modifying factors to enhance counts within the Earth's radiation belts.

Electron fluence values are well below the Active threshold and are most likely to remain below through the next four days.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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